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MONTREAL WATER WORKS

THE REPORTS

OF

WALTER SHANLY, Esq., T. C. KEEFER, Esq.,

AND

JAMES B. FRANCIS, Esq., of Lowell, Mass.,

REVIEWED BY

WILLIAM RODDEN,

Alderman.

MONTREAL, *March*, 1869.

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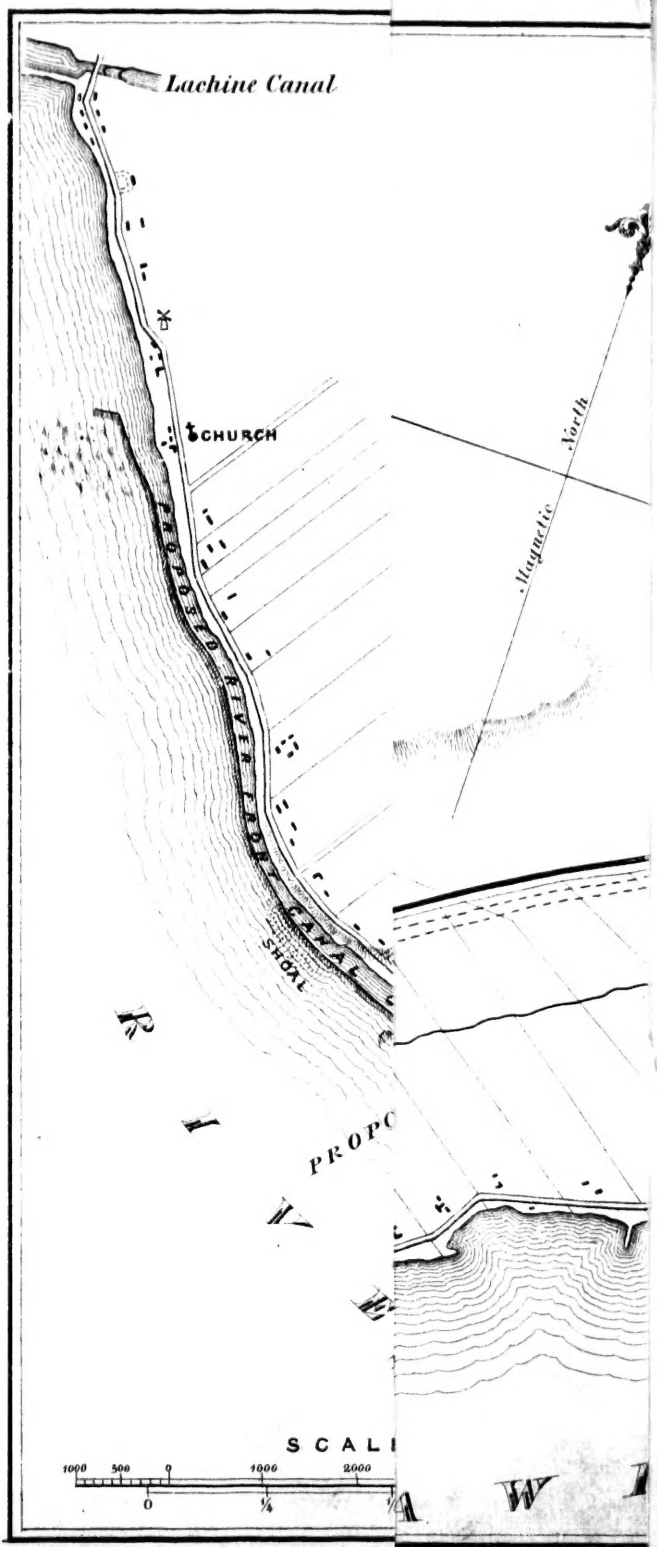
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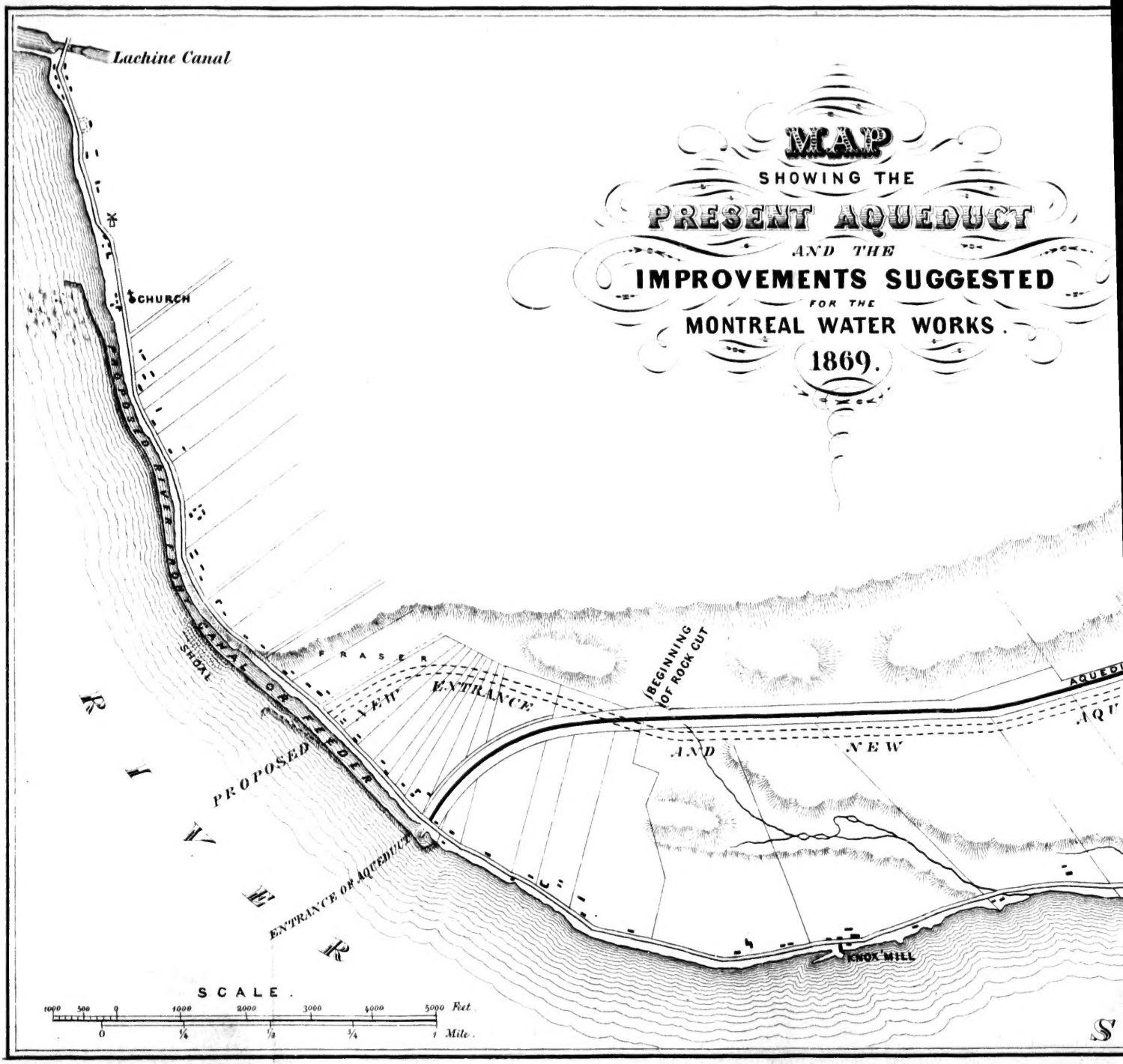


MAP

SHOWING THE

PRESENT AQUEDUCT

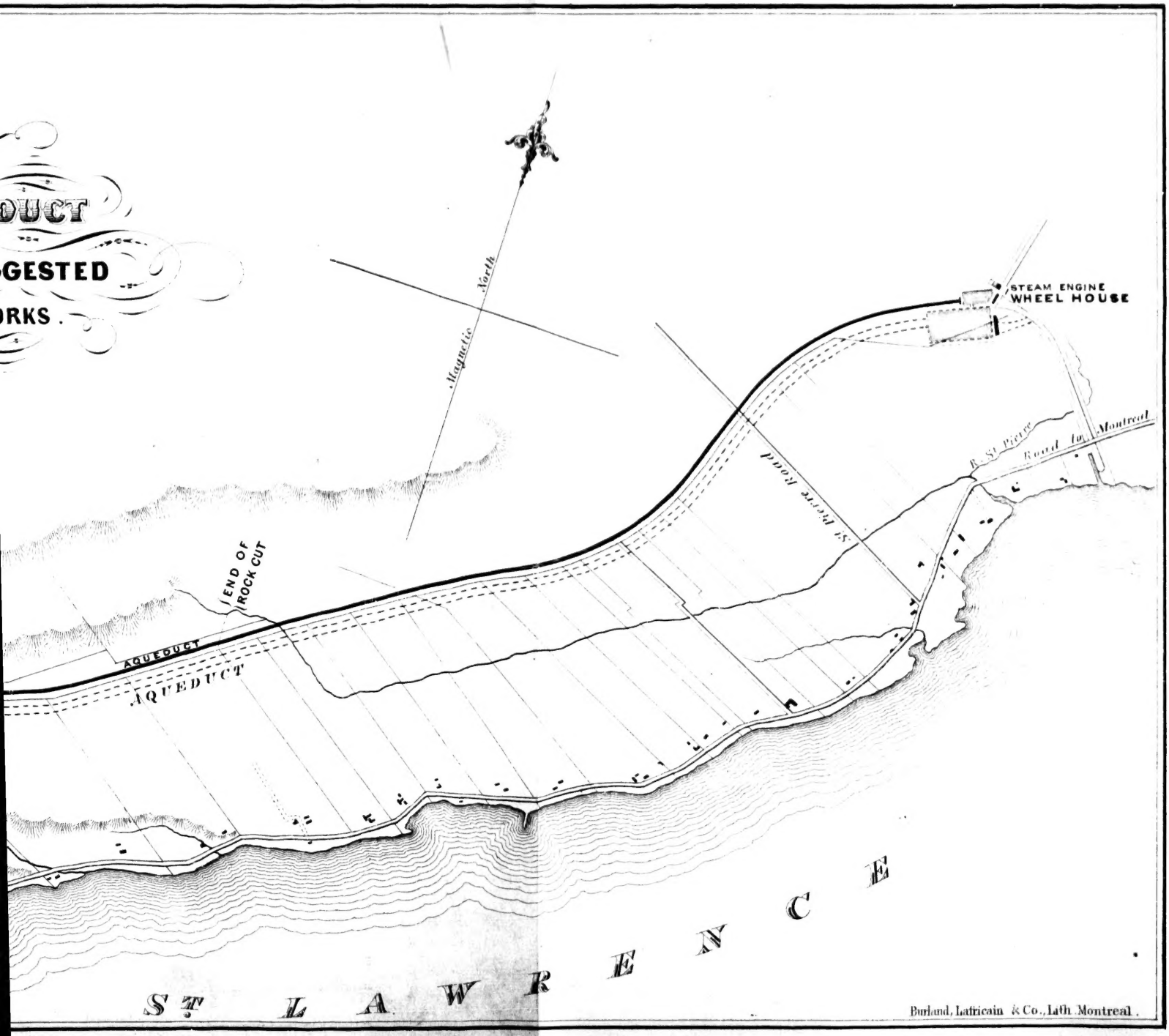
AND THE

IMPROVEMENTS SUGGESTED

FOR THE

MONTREAL WATER WORKS.

1869.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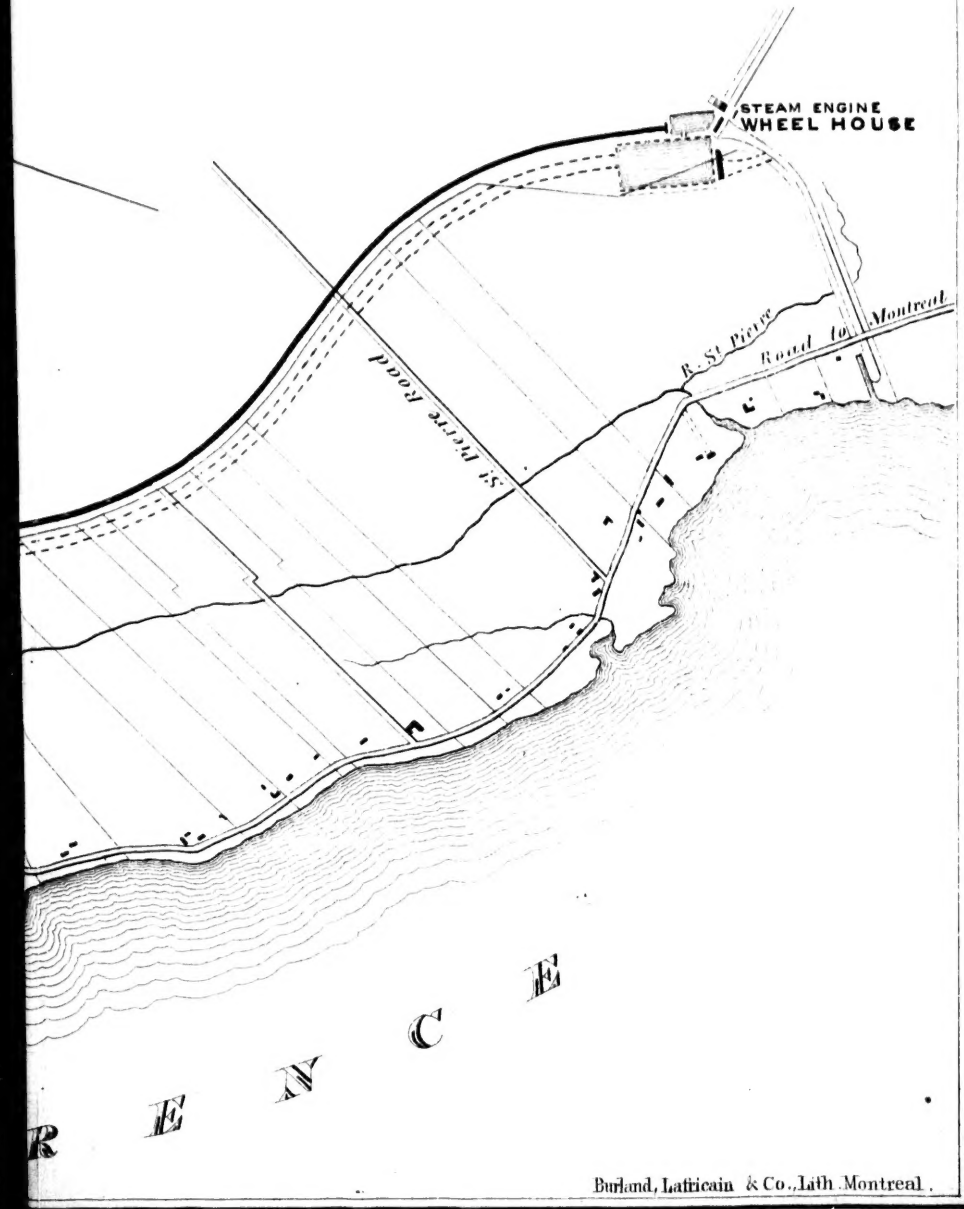

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MONTREAL, March, 1869.

To His Worship the Mayor, WILLIAM WORKMAN, Esq.,
Aldermen, Councillors, and
Citizens of Montreal.

GENTLEMEN :

The present condition of the water supply for the city of Montreal, the large outlay already incurred, the future adaptation of the Water-works to the steady growth and importance of this city, together with the large amount of real and personal property at times exposed to destruction by fire in consequence of irregularity of the water supply, will, I hope, be sufficient excuse for a member of the Council appearing in this form to review the opinions of the eminent engineers who have been consulted on the subject by the City Council.

In referring to the engineers' reports, I have endeavoured to discharge a duty I owe my fellow-citizens, without giving offence, while shewing what I observe to be for, and what against, their interests in this matter. Although I have been several years in the City Council I have not been a member of the Water Committee, and my numerous engagements in other civic departments did not admit of much attention to the details of the water department, until the troubles of last winter's short supply impressed me with the importance of a thorough acquaintance with the subject: therefore it has occupied my attention for several months. The result of which I now respectfully submit.

I am, Gentlemen,

Yours faithfully,

WILLIAM RODDEN.

REPORT.

INSUFFICIENT WATER SUPPLY AND REMEDY.

The want of a sufficient supply of water in the winter of 1867-68 led to a close examination of the cause of such a strange occurrence, which had, for the second time, exposed citizens to dreadful inconvenience and loss, while a large sum of money was expended by the Corporation in temporary relief. The superintendent obtained, when requested, tests of the effect produced upon the aqueduct by the lowness of water at the entrance, the fluctuations in the water level there, the severity of the season, and the accumulations of ice obstructions in the aqueduct, which together produced a contraction of the water way to 54 feet area, reducing the supply upon the city to less than one-third of its requirements, leaving the higher levels at the mercy of water-puncheons, a fate also at times shared by the lower levels of the city. These facts were submitted to the Council, and their consideration by the Water Committee led to the reference of the matter to Messrs. Shanly, Keefer, and Francis, for their respective reports on the subject, which were duly received and considered. The three engineers agree that the present aqueduct is insufficient, that it must be extended and enlarged, or a new one of larger size made; pending which undertakings, temporary assistance must be immediately secured. Further than this the gentlemen do not agree. Mr. Shanly urged the immediate construction of a steam engine to provide against a repetition of the trouble of last winter, as, in his opinion, it would be impossible in one season to provide any other reliable remedy, while the city should determine upon enlarging the present or making a new canal. Mr. Keefer suggests another turbine-wheel, alteration of stop-gates, extending entrance, and other works, which, he thinks, will guard the city for a season against similar difficulties, urging, as an effectual remedy, the enlarging of the present aqueduct and its extension up the river

bank to the church near Lachine, and reservoirs for storage of water. Mr. Francis does not name the means of "temporarily supplying" the deficiencies of water to the city while the new works are in progress; with reference to which he says: "To enable the works to furnish the required additional supply, either the present canal must be enlarged or an additional canal be constructed." "If the enlargement of the present canal is anticipated at an early day, the question arises, whether it had not better be undertaken at once, *and dispense entirely with the proposed extension.*"

Acting upon these reports, the Council chose the suggestion of Mr. Shanly, and ordered a steam-engine to pump 3,000,000 gals. daily into the reservoir, which is now on trial; and the Water Committee ordered surveys and estimates of the costs of the different plans suggested. These estimates, made by the superintendent of the Water-works, have been placed in the hands of members.

Before arriving at any conclusion in reference to the future expenditure of money, it is necessary to examine the suggestions of Mr. Keefer, in his report of 1868, whereby, in his opinion, the present aqueduct can be so altered and extended as to satisfy all demands upon it for several years to come, and to compare his views with those of Messrs. Shanly and Francis.

MR. KEEFER RECOMMENDS

1st, Stop-gates at entrance to regulate fluctuations, and the forming of a large deep-water basin.

2nd, Lowering the breast-wheel.

3rd, Erection of a new turbine at wheel-house, and lower tail-race.

4th, The extension of the aqueduct by crib-work or embankment in the river, upwards along the river front as far as may be required from time to time, till it may reach Lachine.

5th, Enlargement of the aqueduct.

6th, Reservoirs to be filled from April to December, and drawn upon in winter, or when the progress of works might require the water out of the aqueduct.

We are yet without any complete estimate of the cost of the foregoing. Mr. Keefer says the construction of the part which

"should be done in next six months will not cost more than $200,000;" add for extension to Fraser's, $75,000; total, $275,000. This sum will not cover enlargement and extension to the church and reservoirs, of which he says: "It may be considered desirable, when the estimates are obtained, to undertake them at once." From these proposed changes and additions, and his own remarks on them, I infer that at best for a portion of that sum the city will have only expensive experiments, and other works which may serve for a time, pending the execution of such additional works as may be necessary to carry out enlarging, extension, and reservoirs, which, together, are said to be the only reliable means of constant water supply for the city and its annual increase.

Mr. Shanly and Mr. Francis have considered Mr. Keefer's views, and in their reports sufficiently clearly indicated their opinions without openly condemning his. What these opinions are may be inferred from the following sentences taken from their reports:—"Assuming the up-river extension or feeder to be carried out, the time must soon come when the supply in winter would be insufficient, and the troubles of past winters be repeated." "If a canal or feeder in the river was made, without paying the owners of the river front large sums of money therefor, you could not cut them off from access to the water of your canal, and in a variety of ways the throwing of it open to them might render the water liable to suffer disturbance and contract impurities." "Nor would the hydraulic results be wholly satisfactory, not without also giving increased capacity to the existing works." *An enlarged or new aqueduct is an inevitable element of any plan "to enable the works to furnish the required additional supply."*

Speaking of Mr. Francis, Mr. Shanly says,—"I found him very decidedly inclined to the construction of a new canal, pure and simple, with the lowest known stage of the river for the standard head of water, as the most certain remedy for the difficulties of the past, and as the plan best adapted by giving it ample proportions to ensure an unfailing supply in the future."

Careful examination of these reports cannot fail to convince us that Messrs. Shanly and Francis are about agreed as to the cause of our water troubles, and the best and safest remedy;

also, that from the language they use, they do not consider Mr. Keefer's plans the proper ones to adopt. Thus far the Council adopted Mr. Shanly's recommendation to provide a steam-engine as a means of temporary relief. Having done so, and having set aside that part of the suggestions of Mr. Keefer, the question to be now determined is, Will we go on as advised by two out of the three eminent gentlemen called in to help us through this important question, or will we be justified in dismissing their views so forcibly put and accept the contrary advice offered by Mr. Keefer? I have no difficulty in admitting that where two such men agree, the recommendations of the third one should be set aside, and in support of that course I may urge—

1st. The high and independent standing of Messrs. Shanly and Francis, professionally and otherwise, entitle them to unreserved confidence.

2nd. They are not wedded to, nor have they been in any way connected with, any previous plans or the progress of the works thus far: therefore they are unbiased and free to consider things as they found them.

3rd. They echo no doubtful sounds, report no partial remedy, but clearly and emphatically point to the only reliable means of safety for the future—an enlarged or new aquedect.

4th. An examination of the facts in connection with the winter state of the aqueduct, the tests and trials, experience of the past, and the estimated cost of the proposed projects, will support their recommendations.

To arrive at the best means of accomplishing the much desired result in due time and in the best way is our next and most pressing duty. Here, it is admitted, a degree of embarrassment is felt, difficult and trying, which can only be overcome by comparisons, study, and calculations. It is believed that the steam-engine, when fully proved, will afford relief when the water is low, will help the water-wheels when there are obstructions in the aqueduct, will prevent the necessity of drawing down the head which lowers the ice and increases these obstructions in very cold weather, and will render great assistance in case of accident to the canal, or while new works are progressing; but

it does not obviate the necessity of making preparations for works to give the city a permanent and reliable supply of pure water from the river to the wheel-house. Additional steam-power on the river side and gravitation supply have been advocated, but must now be dismissed, because of their expense and difficulty as compared with additions to the system in use, upon which so much has already been spent, and which can within the next four or six years be made perfect beyond a doubt, if the expense is approved and power obtained to execute the works.

The three engineers agree in recommending that whatever is done should be with reference to and a part of future operations. Therefore, we are in duty bound to adopt a comprehensive and complete system once for all, and determine what portion of it must receive our immediate attention, and what may stand for future performance. The citizens will no longer tolerate a system of annual additions with constant uncertainty.

There are three projects for consideration which may be designated A, B, and C, each of which may be divided into sections *one* and *two*. Section *one*, in each project, to provide relief against such difficulties as occurred last winter. Section *two*, in each project, to shew the continuations of the works which may be necessary for the future supply of the city.

Project A.

Section 1 is another turbine-wheel at the wheel-house at a lower level, lowering the breast-wheels, removal of stop-gates to entrance, deep still water basin at the river, and constructing a canal or feeder up the river to Fraser's; also enlarging the aqueduct from the Rock-cut to the river. Section 2 is continuing the crib-work canal or feeder up the river as far as may be necessary, and whenever the additional head may be required; also completing the enlargement of the aqueduct downwards from the head of Rock-cut to the wheel-house.

It is not necessary now to consider the utility of "another turbine at the wheel-house;" that was set aside when Mr. Shanly's views are adopted and an engine put up to do that work. The wisdom of that course is now clear. With the small quantity of water which is passing through the aqueduct this

winter, it would not have been possible to supply the city with water by the pumping done by any description of water-wheel.

The head of water to the present turbine wheel is varying from fourteen to fifteen feet, and quite high enough to work it well if the supply was furnished to it; but it cannot be kept at work because it draws down the head at the wheel-house, the water way in the aqueduct not having the capacity to give the supply as fast as it is required; and when the water is drawn from below the ice faster than it enters from the river, the ice sinks until it reaches the bottom; the obstruction thus becomes complete, and the city is left without water until the ice is removed and the channel cleared.

"*The lowering of the breast-wheels*" is a more serious undertaking than supposed. Such an operation would disturb all the machinery of the wheel-house and its supports, which in all probability could not easily be replaced and made as secure as at present. Alterations to such works are always attended by great risk, and it is next to impossible to make the old and new work connect as securely as the original. A small amount of money spent in another way might serve towards altering inlet of water to the wheels. Any alteration to the wheels will be useless until the aqueduct is made large enough to supply the water required to work them in winter. The wheels should not be lowered excepting as a last resort, particularly as it is only for a short time during low water that they are not fully supplied. Furthermore, inside of ten years hence additional wheels will be required, the placing of which at a lower level will be worthy of consideration.

"*Removal of the stop-gates to the entrance of the aqueduct.*" —I have much difficulty in obtaining any information of the reliability of this proposition. What I do get is, that it is considered by most competent persons to be an experiment of very doubtful character, which can only be made serviceable under a particular head of water and state of the weather which may not occur together.

"*Deep still water basin at river entrance of aqueduct.*"— Such may or may not be of great service there. Much will depend upon the position of the work, the water levels in the river, and the degree of frost while the water is at a particular

height. The rock obstructions in the bed of the river, at and above the entrance of the aqueduct, and the fluctuations of the currents and depth of water there, naturally affect the operations of any entrance. Previous experiments have been unsatisfactory, and nothing short of a trial can determine the exact result. The question presents itself—Is it worth while or safe to expend anything more on experiments? particularly for such meagre results as those promised by Mr. Keefer himself. Speaking of the change in stop-gates and the basin at entrance he says—"These simple measures, I *believe*, will have the effect of diminishing by at least one-half the ice difficulties in the aqueduct." The fact is, that the "ice difficulties" during the last week of February and first two weeks of March, 1868, reduced the water area to 54 feet and the pumping pressure from 80 lbs. to 40 lbs., while the river level varied from 35 to 36 feet above datum. This state of things reduced the supply to 2½ millions pumped upon the city, at and below St. Catherine Street, the power being insufficient to reach the higher levels. On the 20th of December last the ice difficulties of this season commenced: the area or water way was reduced to 190 feet, and the supply brought down to 4¼ millions of gallons daily; since which time the gradual increase of ice and frazil reduced the water area in January to 140 feet, and the pumping pressure was 70 to 75 lbs., producing only 2¼ to 3 millions of gallons daily—a part of the time pumping upon the higher and a part upon the lower levels of the city; and the reservoir was drawn down several feet to assist the consumption, while portions of the city were alternately deprived of water. On the 17th of Feb. last the thickening of the ice had reduced the water area to 104 feet. With this supply of water from the aqueduct, the "turbine" water wheel and the steam-engine pumped together about four millions of gallons, a portion going into the reservoir, the water in which was raised during night, the rest going directly to supply the city. Of the four millions pumped that day the superintendent estimates only about one by the turbine and three by the engine. On the 13th of this month of March the ice had reduced the water area to 58½ feet. Not much pumping could be done with the wheels; the engine was affording a moderate supply. It is admitted that, without the

engine, the city could not now be supplied, the mildness of the winter (with a slight decrease of head at the river entrance) gives now 58½ feet against the 54 feet water area of this time last year. These facts cannot fail to shew that the change in stop-gates and deep water basin at entrance would be of little service, and, without increasing the size of the aqueduct, it is impossible to keep a full reservoir or supply the city.

"*Continuing the basin at entrance up the river, and by crib-work or embankment along the river front forming a canal or feeder, and perform the same by sections as required.*"—This portion of project A will have to be carried up to Fraser's to compare with the new entrance there proposed as part of projects B and C. To understand the difficulties attending the formation of a canal in the river, it is necessary to examine the place and the soundings taken. The work would have to be made on a sloping river bottom, in a depth of water varying from 5 to 30 feet; in some spots the bottom suddenly drops from 5 to 15 feet, 12 to 26, 15 to 30, and 18 to 35 feet depth, and the current in places at the upper end is such as to carry "ice shoves against the large boulders with such a force as to rattle the rocks together like as many marbles." All along the river front there is a road dotted with stables, farm houses and cottages, which must increase in numbers; the inhabitants and cattle have access to and could not be kept from the water. Therefore the difficulties and uncertainties of construction, the exposure to injury of a perishable work and the expense of maintenance, the damages incurred by disturbing the road and vested river rights, as well as the serious objection to suffering unavoidable pollution of the city water supply, renders objectionable the extension of the aqueduct or feeder to it along and up the river front.

"*Enlarging the present aqueduct.*"—This is the final work necessary to make project A of future value, and its execution will be attended with more difficulty than at first appears. To enlarge, it will be necessary to let the water to a great extent out of the aqueduct, and at times wholly out, while working on the lower part of sides and on the bottom; while this work is being done, other means must be adopted to furnish water to the city. This will materially add to the expense, for engine-house, engines, pumps, and a new rising main from the river. Had enlargement

been deemed best as a part of future operations, the engine now going up should have been placed at the river; as it is, we must infer it has been thought best to ignore enlargement in consequence of the expense and difficulty of supplying the city while it was being done. As shewing that Mr. Keefer himself admits that his recommendations should be accompanied by an increase in the size of the canal, I quote his words:—"For the future, whatever more be done, it should be as part of a comprehensive plan." "Estimates of the extension and enlargement are required." "Much may be done this summer to improve the aqueduct for winter works *by enlargement at the worst portion*—the deep cutting below the entrance." "Every day enlargement is postponed the difficulties will be increased from the increasing volume required to supply the wheels." I may remark here that in these quotations from his report, and in his own words, we find what seems an important and significant admission, *i.e.*, that his other suggestions are but tending to afford temporary assistance, while we proceed to enlarge the part referred to of the present insufficient aqueduct or canal, and extend it up the river front. That being done, what remains for the future would be the continuation of the enlarging to the wheel-house, and of the extension to Lachine, both of which, he admits, are necessary. Extension, enlarging, and elevating the banks of the canal to receive the extra head of water caused by extension, cannot be separated, and their expense, as compared with other projects which will be attended by less inconvenience and more reliable results, will enable us to determine without much difficulty which should be undertaken.

Project B.

Section 1 is a new and larger entrance below Fraser's Hill, extending along the valley downwards until it reaches the present aqueduct above the Rock-cut. Section 2 is enlarging the present aqueduct from the new entrance at the head of the Rock-cut to the settling-pond.

The new and large entrance to the aqueduct is supposed to start from the head of the Rock-cut, there join the old canal, cutting upwards across the farms until it reaches the valley near Fraser's, turning into the river below the hill, somewhere about

3 to 3½ thousand feet further up than the present entrance, affording 10 inches more head, and protected by a projecting point and shoal above it where the current inclines more from the shore, carrying from the entrance, instead of towards it, floating ice, frizil, other obstructions and pollution. This new cut is supposed to take the place of part of Mr. Keefer's plans, *i.e.*, enlarging the present entrance as far as Rock-cut, the removal of stop-gates, the construction of a deep still water basin, and the extension of the present aqueduct by crib-work or embankment as far as Fraser's, to reach the same point in the river as the entrance of the new cut, with the same capacity and head, but obtaining it by another and different work. It is supposed that the execution of this new work, from the Rock-cut to Fraser's, will save us from further trouble for several years. In this opinion I do not quite agree, inasmuch as I believe that, when the winter season is very severe, there may be such trouble from ice obstructions, just above the settling-pond or basin at the wheel-house, as to render it necessary to extend that basin some distance upwards, or enlarge the aqueduct there, thus giving it additional capacity, and prevent the damaging effect that the drawing down of water by the wheels may cause at that place.

Close observation and tests during this and last winter, of the way ice obstructions and frazil are drawn by the current in and along the aqueduct downwards, gradually becoming part of the ice covering the water, have shown the advantages to be secured by a new entrance at that place, with a large canal, which will reduce the current to less than one-half of the speed, drawing in less ice and frazil, and affording room for what little is drawn in to lie up along the enlarged entrance of the aqueduct. It is supposed it will confine a great portion of the ice and frazil obstructions to the new section above the Rock-cut, while sufficient water way will be left to pass the much desired quantity, leaving the Rock-cut and the section below it to contend only with the ice which will be formed thereon by the severity of the weather; care, however, being taken to avoid drawing down the head, and with it the ice on the section near the wheel-house.

To determine which of the projects will be adopted, if any, it is necessary to look at the cost of the first section of project A as compared with that of project B, and at the same time

consider the advantage it would be to have another entrance of a permanent character in a deep bay, not of perishable material, not exposed to wear and tear of ice shoves, not incurring bills of damage for river front, and not exposed to disturbance of the water and accumulation of impurities and filth that would be conveyed to the city water supply by the river front canal if adopted.

Section 2 of this project B would be enlarging the present aqueduct from the head of the Rock-cut to the wheel-house whenever the further enlargement proved necessary. Should the city continue its present annual growth, it is estimated that within six years the second section of any of the Projects, A, B, or C, will engage the attention of the Council, unless such extensive reservoirs be constructed as to retain over two months' supply of the city from Dorchester Street upwards; and even should these reservoirs be made, it would not be safe to neglect at least widening the aqueduct just above, or lengthening the settling basin at the wheel-house. This section of Project B would be the same as section 2 of Project A, and in all respects liable to the same objections, owing to the necessity of drawing the water off the aqueduct and supplying the city by steam and reservoirs while the work is being done, thus adding so much to the expense as to make it a matter of calculation as to whether widening the old or making a new cut would be best.

Project C

Is a new canal throughout, divided into two sections for comparison with other projects. The first section will extend from the river below Fraser's Point, along the valley there to the Rock-cut of the present aqueduct. The second section will be a continuation of the new canal from the head of the Rock-cut to the settling pond at the wheel-house.

The first sections in this and in Project B are the same, both having the new entrance. The difference between these two projects is that one is enlarging the old canal from the Rock-cut to the wheel-house; the other is a new cut throughout. If Project A be dismissed, the choice will rest between enlarging the present canal and making a new one. There are many considerations to be examined to reach

wise conclusions. The remarks made on the difficulties of enlarging in Project A, will apply to enlarging as part of other projects. If enlarging could be done without disturbing the city supply, and without its being necessary to provide other means of supply while the work progressed, there would be much less difficulty in the choice. This, however, cannot be hoped for. Therefore, if the expense of enlarging and keeping up the water supply while that is going on will exceed the expense of a new canal, there will be no difficulty in setting aside the enlarging, and considering the adoption of a new canal of the required size on its own merits.

The advantages to be obtained by constructing a new canal instead of enlarging the old one will be found in the following facts:—The entrance of the proposed new aqueduct below Fraser's Point affords greater protection from ice, frazil, and other obstructions, greater depth of water, and more head; the work can progress without in any way deranging the present water supply; the impurities occasioned by working on the old canal to enlarge it, while water is passing to the city, will be avoided; it will obviate the necessity of incurring a large outlay for temporary works to supply the city with water while it is being done, which expense could not be avoided in any other plan that would afford permanent relief; it will give a volume of water to the machinery at the wheel-house which will ensure ample power to supply the present pumps, and such others as will be added, for years hereafter; and it will give a second aqueduct. One can be used while the other is being repaired or cleaned; one can furnish the pumping power and be extended up the river if such should ever be necessary, while the smaller one would remain to supply the pumps for consumption, the entrance to which would continue to draw its water from a part of the rapids not exposed to filthy obstructions, and as free as possible from the pollution which a feeder along the river side would convey direct to the city supply. The last but not least important fact in reference to the new canal is, that it will not cost more than enlarging and extending the old one, presuming the engineer's estimates to be correct; indeed, it will cost less than extending and enlarging, taking into account the large sum which would necessarily be expended in furnishing the city with

water while enlarging went on to the interruption of the present supply.

A SMALL CANAL.

It must be admitted that the present canal, only 20 feet wide on the bottom, is quite too small. It was a mistake to make it so small. Ice will not form to so great a depth on the large as on the small canal. The depth of ice on the present small aqueduct is often five feet and over, while on the settling pond it varies from two and a half to three feet, and on the Lachine Canal it averages about the same. The experience of mill-owners throughout Canada goes to show that small streams in this climate are not to be relied upon in winter. Fluctuations and obstructions that must arise, and are beyond human control, affect small streams at once, while the large stream has ample room to recover from such difficulties before serious inconvenience arises. It must be remembered that over twenty millions of gallons have to pass through the aqueduct to put one million into the city reservoir. As the city grows the quantity required increases, and with it the draft upon the aqueduct increases the current. A small canal, with a rapid current, is much more likely to carry in ice and other obstructions, and suffer from them, than the larger canal with slower current into it. The winter state of the old Lachine Canal, as compared with the present canal, affords a good example of this. The full importance of a few words from Messrs. Shanly & Francis on this subject should not be lost sight of, *i.e.*, "In a climate such as ours, *size* is the surest mode of obviating winter obstructions in hydraulic works, and it is *very certain* that a wide canal with the lesser head will prove a more effective and reliable power than a narrow one with the greater head." Ten years' experience as owner of a grist mill on a country stream as wide as the present aqueduct enables me to endorse these opinions.

MR. KEEFER'S LAST REPORT.

The latest report on this subject is from Mr. Keefer, and recently published. It furnishes his estimates for a crib-dam feeder or canal from the entrance of the present aqueduct in the river to the Lachine Church, at a cost of $25 per foot—total,

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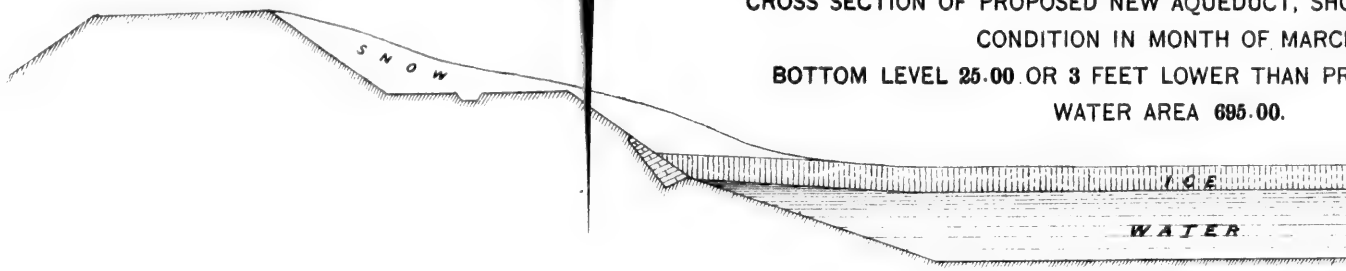
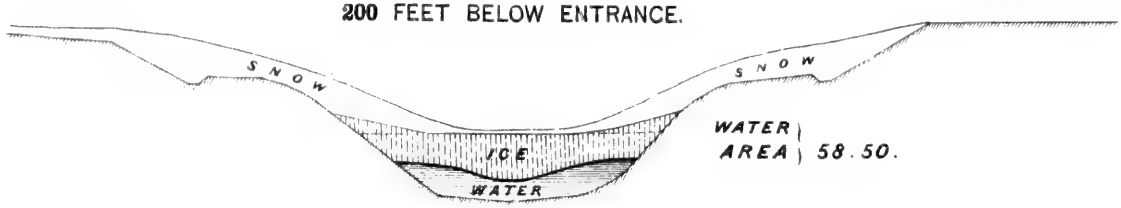


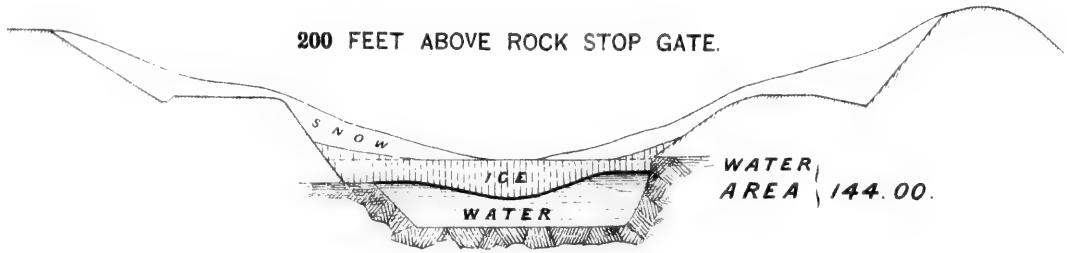
SCALE 20 FEET TO AN INCH

CROSS SECTIONS OF AQUEDUCT, SHOWING ITS CONDITION ON 13th MARCH, 1869.

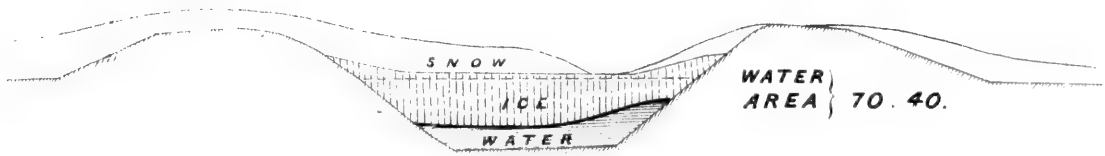
200 FEET BELOW ENTRANCE.



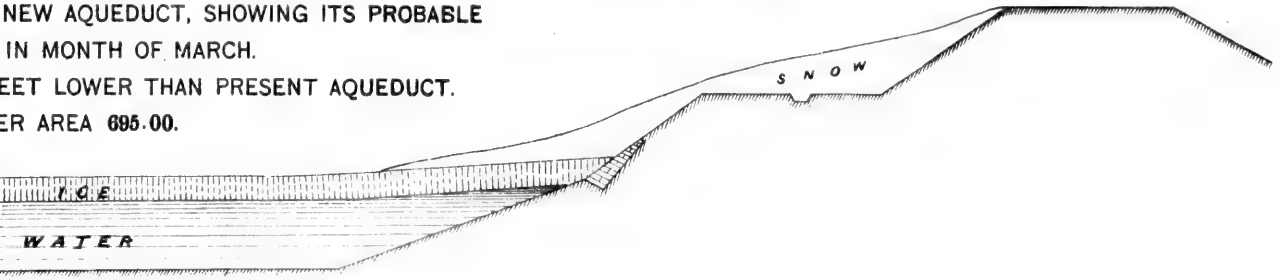
200 FEET ABOVE ROCK STOP GATE.



200 FEET ABOVE SETTLING POND.

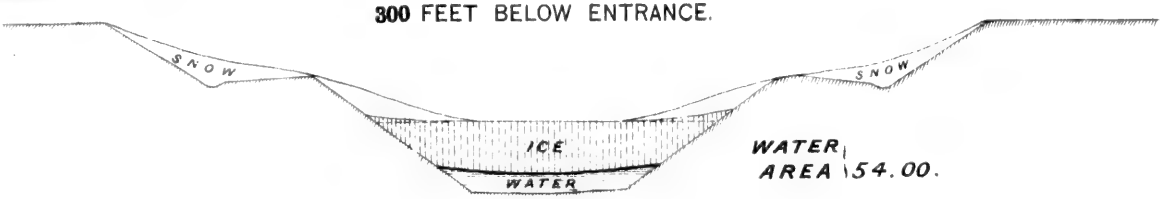


NEW AQUEDUCT, SHOWING ITS PROBABLE
IN MONTH OF MARCH.
EET LOWER THAN PRESENT AQUEDUCT.
ER AREA 695.00.

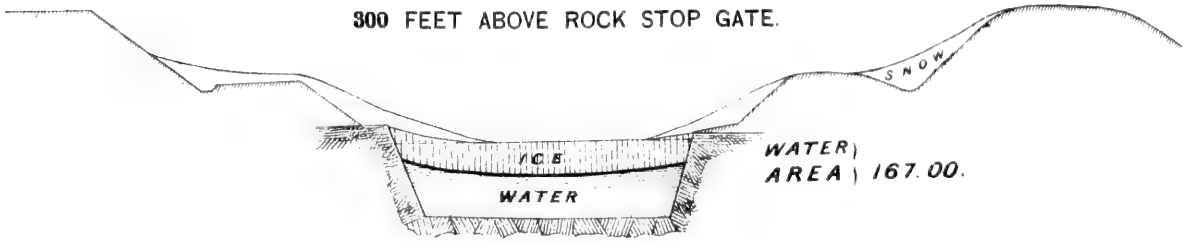


FEET TO AN INCH.

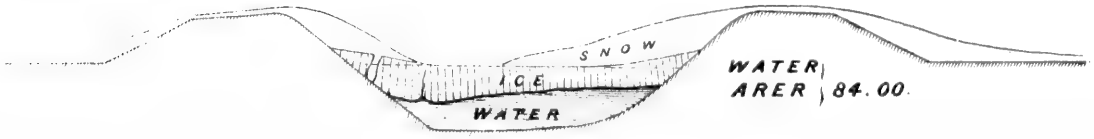
300 FEET BELOW ENTRANCE.



300 FEET ABOVE ROCK STOP GATE.



100 FEET ABOVE SETTLING POND.



CROSS SECTIONS OF AQUEDUCT, SHOWING ITS CONDITION
9th MARCH, 1868

HF

$250,000 — including dredge plant, dredging, filling, finishing with stone on top, and an embankment below water line, along the entire length of the plank sheeting.

This is considered at least $50,000 too low: the lowest estimate obtained here averages $30 per foot for that work in that place. The Government crib-work at head of Lachine Canal cost about $80 per foot. It is not necessary to repeat what has been explained establishing the perishable nature of such a dam, and the difficulties of constructing and retaining it safely in such a place.

The estimate does not provide anything for large payments for land damages, which would be claimed by owners of the river front, fencing along the line between the road and the feeder, bridges and drainage for the farms the whole length of the work. It is not considered out of the way to estimate the cost of land on river front, fencing, bridging, and draining, at $100,000, making the whole cost of the feeder $400,000, to which must be added either the cost of enlarging the present aqueduct, or if that be not done, at least the banks must be raised to give the height necessary for the elevation of water, produced by the difference between the level at the present and the proposed new entrance at the Lachine Church. This elevation of banks Mr. Keefer has omitted, and would cost, including gates, sluices, weirs, alterations, &c., about $50,000 to adapt the works to the extra head. When the whole of the foregoing is accomplished, at a cost of $450,000, not less, we shall have, in winters such as those of 1867-68, 1868-69, where the head at the Church is fluctuating from 38·50 to 39·00 above datum, a supply for the city of about five millions of gallons as is further explained below. The work cannot be executed within two years, perhaps three. When that time comes the requirements of the city will have reached over seven millions of gallons daily, and ere that work would be completed, the city would again require the consideration of means to give a further supply in winter: thus the agitation would be continued to the great disgust of all concerned, and manifest injury to, and complaints against, the City Council.

There is no difficulty in producing abundance of evidence, that increasing the head of water by a feeder or canal along the river

front to the Lachine Church will not alone remedy the evil—additional size as well as head is necessary. This Mr. Keefer seems to admit when referring to enlargement. What the feeder would add to the supply in winter, with the river at its present height, 35·15 at entrance, and 38·72 above datum at the Lachine Church, may be learned only by comparison with what has been done, all other things being equal.

EXPERIENCE OF THE PAST.

The best summer low water test on record was in the end of September and part of October last. The water level at the aqueduct entrance varied from 36.20 to 36·60. When trials were made, all that the wheels would give was five and a-half to six and a-quarter millions of gallons. The consumption of water in the city then being large, the water in the reservoir was at times drawn down two feet, and filled again at night. With a larger aqueduct the water would have reached the wheels in such a volume as to have kept them in full operation without drawing down the working head of water in the settling pond. The increased head to be obtained by the feeder at that season would serve the purpose in summer now, but it is the winter state of the aqueduct, with three to four feet of ice upon it, which reduces its power (even with the feeder) to less than the lowest point reached last summer. For example: in December, 1868, the water area was 190 feet, level at entrance 36·45, pumps giving only four and one-fourth millions of gallons daily. On the 13th March, 1869, the water level at the entrance was 35·15, and at the Lachine Church 38·72. The ice and low water reduced the water area of the aqueduct to 58½; the proposed elevation by feeder would add 96½ feet to it, making 155 feet area. Increased head would add to the power. What this would add to the supply may be learned from the fact, that in February, 1867, the level at the entrance of the aqueduct was 38·60, about as high as the water level at the Church on the 13th of March, 1869, when, if the feeder to Lachine Church was in use, the head of water in the aqueduct would be about the same as it was at the present entrance to the aqueduct in February, 1867, at

which time, and with that height, the winter state of the aqueduct only furnished water enough to enable the wheels to pump about five millions of gallons daily. The head at the wheel-house was drawn down two feet, and it was with great care and management that the further drawing down of the head and the ice was avoided. The city supply was kept up from the pumping and by drawing from the reservoir in the day time, while the water was turned off the city at night, pumping into the reservoir made up the loss and kept it fairly filled. If this was all that could be done in February, 1867, with the same head as the feeder would give if constructed and in use in March, 1869, I am at a loss to understand how it can be expected that the feeder without a larger canal would be able to do more than was done with the same head, or place the means of supplying the city in a more reliable position. This comparison cannot fail to convince us that the additional head, with the small aqueduct, would not effectually remedy the evils now suffered from short supply in winter months, with the river at its present low level, which may occur again. In further support of this conclusion I quote

THE ENGINEER'S OPINIONS.

Mr. Shanly's report says :—" It is plain that the present works, even when not shorn of a portion of their intended usefulness by an untoward winter condition of the river, are fast becoming unequal to the growing needs of the city, and that the time is at hand when measures will have to be adopted for providing a much larger supply of water than they at best are able, or were designed, to furnish. The construction of the 'feeder,' then, would not in itself effect all that is needed." And Mr. Francis says :—" When that time arrives, additional provision must of course be made. To enable the works to furnish the required additional supply, either the present canal must be enlarged or an additional canal be constructed, in order to furnish a sufficient supply of water at the wheel-house to drive the pumps," &c. Mr. Keefer says :—" The enlargement and extension can either

be carried on together, or either precede the other. If enlargement be decided on, it should not be delayed, but commenced at once before the pumping power required to supply the city in summer becomes so great as to compel you to maintain a high level in the aqueduct while you are taking down the slopes."

The three engineers having admitted that additional size of canal s necessary, and the sufferings of three winters having proved it as further demonstrated by the particulars here given, it remains to be determined whether the city will be best served by the execution of works affording partial relief, or by adopting such a plan for future operations as will be lasting and undoubted.

In commenting on the three projects, sufficient has been said to lead to the conclusion that a choice lies between Project A, *extension and enlargement*, as advised by Mr. Keefer, and Project C, *a large canal*, as advocated by Messrs. Shanly and Francis. The latter further says:—"Whether to enlarge the present canal or construct a new one, must depend very much on the cost of the works, and I would suggest that estimates be made of their cost, together with the cost of temporarily supplying the deficiencies of water to the city while the new works are in progress." And Mr. Shanly, after hearing the views of Mr. Francis and the explanations on Mr. Keefer's propositions, says:—"I have no hesitation in recommending a new and large aqueduct alongside of, but distinct from, the existing one, and having its entrance at Fraser's Hill." If it should be determined to make a new and enlarged entrance from below Fraser's Hill to the Rock-cut instead of the river feeder to the present entrance, the next choice will rest between enlarging the present canal or continuing the new one to the wheel-house. When the cost of enlarging has added to it the cost of supplying the city during the progress of the work, and the advantages secured by having a second canal are fully considered, the latter—a new canal—will no doubt be considered the best and cheapest in the end. To make this better understood the estimates of the engineers of the water department are taken, and such additions made to them as seem necessary to place before the public the full

COST OF THE VARIOUS PROJECTS.

Project A.

River front canal, damages to land, fences, bridges and drainage from entrance of aqueduct to the Lachine Church	$400,000
Enlarging the aqueduct to the Rock-cut	146,077
Do. the Rock-cut throughout	445,709
Do. from the Rock-cut to the wheel-house	226,410
Dredges, scows, and other plant	68,200
	$1,286,396
If the river front canal is extended only to Fraser's, to compare with other projects terminating there, deduct	250,000
Total cost of project A to Fraser's	$1,036,396

(Cost of supplying the city with water while enlargement was going on not included in this estimate.)

Project B.

New entrance and canal from Fraser's to the Rock-cut of the present aqueduct	$275,379
Enlarging the Rock-cut section of the present aqueduct	445,709
Enlarging the aqueduct from the Rock-cut section to the wheel-house	226,410
Dredges, scows, plant, &c.	68,200
Total cost of project B to Fraser's	$1,015,698

(Not including cost of supplying the city with water while the enlarged part is executing,

Project C.

New entrance and canal from Fraser's to the Rock-cut section, including dredging (same as project B)	$275,379
New canal alongside of present Rock-cut	478,808
Do. from Rock-cut to wheel-house	285,714
Total cost of new canal from Fraser's	$1,039,901

(Nothing to add, as the city supply would not be disturbed while new canal is making.)

It occurs too frequently, that under estimates are made of the cost of public works for reasons that cannot be approved, and under the impression, that if the whole truth was known, it would

be difficult to secure a commencement of a desirable project. As I have no object to serve, but a desire to benefit the city I am pledged faithfully to represent, I feel it to be my duty candidly to say, that I am convinced, the city will not be quite safe from water troubles in winter, and the means of providing for the annually increasing consumption of water will not be secured, at a cost of a less sum than one and a half million of dollars, including reservoirs and the completion of pipe laying in the city, and that it cannot be well and economically performed in less than six or seven years, at an average annual outlay of $250,000. This would swell the water works loan to four and a half millions of dollars. The present water rates pay the interest and working expenses of three millions. With this year's extension of pipes to streets being rapidly built up, the annual increase of collections will amount to the interest required to pay that accruing on the additional loan to the above named extent, obviating the necessity of imposing any special rate for that purpose. Therefore, I claim that it is only just and proper that the people of Montreal, who by their water payments support the works, should have the means secured to them of obtaining a reliable and permanent supply. Further exposing them to annoyance and loss, as in the past, is most unfair, and tends to impair the confidence of the people in civic government.

RESERVOIRS

Should form a part of the first works to be secured. It cannot be denied that so much valuable personal and real property should not be at the mercy of mere accident, which might at any time occur at the aqueduct, and deprive the city of a supply of water through it. The present reservoir never can be so extended as to alone serve the purpose: it may only be looked upon as a receiving and regulating basin, with which there should be connected, at a higher level further west, a large reserve of water, and another further east just enough lower to be filled by gravitation from the present reservoir. Mr. Keefer very properly says: "Whatever may be expended on reservoirs, value will be received; but every year reservoirs are postponed, the cost of land will be enhanced," &c.

It will be admitted that any new debt incurred for water works improvements should be applied to form part of what will be

required by the future city of Montreal, and that this is the time to determine whether that shall be, a canal constructed by crib-work in the river, enlarging the present canal, or an entirely new one.

The information now communicated in reference to the expense and difficulties of the two former, can hardly fail to convince an unbiased reader that the latter—a new canal—possesses advantages worthy of consideration, and is the work which should be looked forward to as an unavoidable necessity to secure a permanent and reliable water supply for this important city, during low water in winter months.

I do not claim the right to dictate or unduly influence action in any particular direction, yet I feel this paper would not be complete without an indication of the direction in which I would labour to accomplish what I believe necessary, and that would be what is offered for

FINAL CONSIDERATION.

1st. Secure the adoption of the best plan for a future and reliable supply of water, *i. e.*, A NEW CANAL AND RESERVOIRS.

2nd. The section of the canal from the Rock-cut to the river should be first made, and at once; also, one at least of the new large reservoirs should be finished for storing not less than 30 days' supply.

There is reason to believe, that notwithstanding the new entrance, the size of the aqueduct below the Rock-cut will be insufficient during low water, and for six or eight weeks of mid-winter, to pass the quantity required to work the wheels and pumps. At such times it would be much safer to use the steam engine than to risk drawing down the ice by so heavy a consumption of water as depending on the wheels, to give the supply, would require. Furthermore, a reserve of thirty days' supply might save the city from trouble during the delay which may occur between completing the new entrance and continuing the new canal to the Wheel-house.

3rd. The increasing demand for water is likely to require, that as soon as the first section of the new canal and the first large reservoir are completed, the second section of the canal from the head of the Rock-cut to the wheel house should be com-

menced, and the work continued until completed, within the six or seven years, ere which time there is but little doubt the city will require ten millions of gallons daily, not much more than one half of which quantity can in winter be supplied by the present aqueduct, even with the additional head proposed, and with the water as low in the river as it has been during this and last winter.

4th. The land should be secured at once for the new canal and reservoirs named and calculated for as part of the whol plan costing the one and a half million of dollars when finished; but the work upon one reservoir and the lower end of the new canal need not be commenced till proof of approaching need is visible. Much relief from the present water difficulties may be obtained by the expenditure of a less sum now, by adding to it from time to time as additions to the works may be necessary. If however the present low winter level of water in the river should continue, the work on the large aqueduct may proceed till completed.

ANOTHER VIEW OF THE CASE.

Other means of escaping from the difficulties of the water question have been freely spoken of; and may be considered as only postponing the expenditure of over one half of the cost of the new canal throughout and the two new reservoirs.

In this connection it has been argued that, the new entrance to the Rock-cut and one of the reservoirs, with another steam engine, would answer every purpose for several years, and avoid the loss of interest which would be involved by the expenditure of the whole of the one and a half million dollars within the next seven years.

It may be said in reference to such a proceeding, that whatever is expended on the new entrance and the reservoir may fairly be considered as part of a reliable project for future completion, and good value for the cost as far as it goes. Putting up a second engine should not be entertained hastily; all other available means should be first exhausted. With the rapids of the St. Lawrence at hand there should not be any further necessity for steam power.

THE FUTURE OF THIS CITY.

It may not be saying too much for the City of Montreal, to assume that ere long the extension of its limits will demand a

great additional water supply, and require the prompt execution of such works as will give the quantity. Such an event should now be looked forward to, and the Council should be encouraged to adopt an enlarged project which would afford ample means to meet the case when finished.

It may not fall to the lot of many of the present administrators of civic affairs to live to see our fair city double its population and wealth in the next, as it has during the past fifteen years. Yet there is not the least doubt such will be seen; indeed more may be realized if the proper direction onward is given to the natural and artificial advantages enjoyed. Attention is now being directed to the long needed improvements in the water and rail connections between this city and the parts of the country which are in more immediate connection with it; the proper development of which, and its resources, must serve to build up this city more rapidly.

While legislative and municipal progress tends to a proper provision for future greatness, there is every reason to believe that the City Council will not remain behind the age, by the adoption of any merely partial remedy for the difficulties experienced in the city water supply, which would only put off the evil day; but, on the contrary, it is confidently expected, that a reliable and permanent means of relief will be adopted, which may progress in sections as required, will be creditable to the Council, and prove satisfactory to the citizens.

MAP AND DRAWINGS.

The accompanying map of the aqueduct as it is, and the proposed changes or new canal as copied from the plans of the Water Department, are given for public information, without assuming any responsibility in reference to the proposed position, size, character or cost of the work. The details and location should be a matter for the investigation and supervision of the best and most reliable engineering skill the city can command.

The drawings of sections of the present aqueduct, will enable readers to judge more clearly of the difficulties which have to be met in consequence of the ice obstructions in such a small canal.

And the difficulties of supplying the quantity of water required to drive the wheels and pumps through such a small water way as that which is shewn to be all that existed, on the dates the test measurements were made by the Water Works engineers.